10

MULTIMEDIA TECHNOLOGY

In this chapter, you will learn:

♦ About the fundamental workings of multimedia technology
♦ About many multimedia standards and how they have helped shape the industry
♦ How to support many multimedia devices, including CD-ROM drives, sound cards, and DVD drives

The ability of PCs to create output in a vast array of media—audio, video, and animation, as well as text and graphics—has turned PCs into multimedia machines. The multimedia computer offers much to take advantage of, from video conferencing for executives to teaching the alphabet to four year olds. This chapter examines multimedia devices, what they can do, how they work, and how to support them.

The goal of **multimedia** technology is to create or reproduce lifelike representations for audio, video, and animation. Remember that computers store data digitally, and ultimately as a stream of only two numbers: 0 and 1. In contrast, sights and sounds have an infinite number of variations. The challenge of multimedia technology is to bridge these two worlds. The key to doing this is twofold: reduce the infinite number of variations to a finite few, and record as many as needed to reproduce an approximation of the original sight or sound, without overloading the capacity of the computer to hold data. These tasks require (1) a lot of storage capacity and (2) the ability to process large quantities of data at high speed and at the lowest cost possible. This chapter focuses on how the industry is attempting to meet the challenge.

When studying multimedia technology, look for these two features: the need for large amounts of storage capacity and the ability of a computer to handle this large volume at high speeds, including sophisticated methods of sampling sight and sound. Also, as you study, look for the attempts of the industry to standardize methods of sampling and storage so that different types of software and hardware are as interchangeable as possible, considering the fast-changing technology that manufacturers must contend with.

THE RIGHT TOOLS FOR THE JOB

Desktop computer systems are designed for three major purposes: low-end systems designed as e-machines and thin clients, mid-range systems designed for desktop publishing, home computing, and general business needs, and high-end systems designed for computer-intensive engineering applications. E-machines simply access the Internet and use its applications, and thin clients use the data and applications served to them by network application servers. Generally these machines are not intended for upgrade and might include a system board that has many proprietary components with no room for expansion. High-end systems meant for engineering applications focus on powerful and sometimes multiple CPUs, large amounts of memory and hard drive space, and use powerful operating systems such as Windows 2000 or UNIX.

This chapter focuses on the mid-range computer system designed for desktop publishing, graphics design, home entertainment, multimedia presentations, and entertainment from the Internet. These systems benefit from a CPU designed with multimedia in mind and from powerful graphics accelerator cards and sound cards. In addition, most of these systems can interface with multimedia devices such as camcorders, digital cameras, and scanners. Applications for these systems include web-authoring software, desktop publishing, multimedia presentations, and games. This section looks at the hardware and software requirements for each.

Technicians who help make purchasing decisions about multimedia hardware and software need to stay abreast of the latest innovations in the marketplace as the technology changes rapidly and choices and price ranges abound. Before you purchase or make a recommendation about the purchase of a new computer system or a peripheral, research the purchase. Some of your best resources are:

- Other satisfied users, retailers, books, the Internet, and computer service centers

- Trade magazines, such as *PC Computing*, *PC World, Home PC*, *Computer Shopper*, *PCNovice*, *PC Magazine*, and *PC Today*. Look for reviews describing hardware and software, how they work and popular features.

- Special-interest web sites such as *www.imaging-resource.com*, which focuses on digital imaging, or Tom's Hardware Guide at *www.tomshardware.com*, which focuses on hardware

- Magazine web sites, including:

www.zdnet.com	*Several technical magazines*
www.cshopper.com	*Computer Shopper*
www.pcmag.com	*PC Magazine*
www.pcworld.com	*PC World*
www.pccomputing.com	*PC Computing*
www.pcguide.com	*PC Guide*

Typically, the minimum software and hardware requirements for an adequate desktop-publishing, Web-authoring, entertainment, or multimedia presentations system include:

- A Pentium II–compatible computer or higher with a hard drive and a minimum of 64 MB of RAM, a mouse, and a high-resolution color monitor and video card

- A word-processing software package

- A scanner and related software

- A laser printer or ink-jet photo-quality printer

- A graphics software package to create and/or edit graphics

- Optional equipment for web authoring and multimedia presentations such as a video-capturing card and a digital camera

- For desktop publishing, a page composition software package, such as Adobe PageMaker (see Figure 10-1), to bring together all the individual elements of text, graphics, and scanned images into an easy-to-read and visually appealing finished document

Figure 10-1   A page composition software package

- For web authoring, an authoring tool such as Microsoft FrontPage or Netscape Publisher, which brings together individual elements of text, graphics, video, scanned images, and sound into one or more web pages

- For multimedia presentations, a presentation package such as Microsoft PowerPoint, which ties individual elements of text, graphics, video, and sound into a sight and sound presentation

■ For entertainment, access to the Internet with a fast enough connection to play streaming audio and video data and, for game playing, a fast graphics accelerator card

If your budget is limited, spend money on the computer itself rather than the peripherals. A computer system is no faster than the CPU, no matter how sophisticated the peripherals. A laser printer is an expensive item; you can use an ink-jet or dot matrix printer for rough drafts and then take your work on disk to another system with a photo-quality laser printer. By postponing the purchase of the laser printer, you may be able to afford a faster Pentium processor or more memory on the system board. The speed and reliability of the computer are invaluable.

Bits Are Still Bits

Just as with every other component of a microcomputer, multimedia devices represent data as a series of 0s and 1s. For example, a black-and-white scanner sends a light beam across an image and reads that image as a series of black and white dots. Each dot is represented as a 1 or 0, and is stored in a file called a **bit map file**. A sound card captures sound, converts each segment of the sound into a series of 0s and 1s, and stores these in a MIDI file that can later be interpreted once again as sound. A video-capturing card captures a segment of video and converts it to—you guessed it—a series of 1s and 0s, when it is stored in a file.

Another uniform quality of multimedia devices is that each device transfers its data over the same bus to the CPU; the CPU processes the data in the same way and sends it as output to a multimedia device, just as it does with other devices. So each device may require an IRQ, a DMA channel, an I/O address, and room in memory for its BIOS or drivers. When working with these devices, don't be intimidated by their complexity. All their basic computing needs are the same.

Multimedia on a PC

Multimedia has traditionally targeted the home market, with games and more games at the top of the list of multimedia software. Until recently, the trend in the business market has been to acquire more powerful PCs for computing, networking, and remote management.

Now, however, business use of multimedia PCs is the norm. Video conferencing, computer-based training (CBT), and multimedia presentations are now common on the corporate scene. This trend affects the development of hardware and software, as both attempt to satisfy market demands.

Another important fact that helps to understand development trends is that, in the evolution of computers, hardware must improve in advance of the software designed to use it. A good example of this is the MMX (multimedia extensions) technology used with the Intel MMX Pentium CPU. When the hardware technology arrived, more software became available to use the technology. In the future, you can expect continuing improvements in multimedia hardware, which will continue to lead to the development of new software.

Evidence of the inroads multimedia technology is making into the business market is the introduction of the Pentium III CPU, which is marketed as a high–end CPU for servers, yet includes SSE, which is technology designed to improve on MMX multimedia processing.

Multimedia Fundamentals

Before you study multimedia technology, examine the special challenge confronting multi–media technology: reproducing something that is continuously changing (referred to as ana–log, as discussed below) such as sights and sounds, on a PC, which is incapable of making continuous changes because it is digital. It has only two states and can only change from one state to another, with no gradations in between.

We have been comparing the word "analog" to "digital," but what exactly do we mean by that? Analog comes from the same word as "analogous," and means "the same," implying smooth, continuous transition that lacks distinctly defined gradations. "Digital" comes from the Latin word *digitus*, which means a finger or toe. The term "digital" originates from our 10 counting digits and implies distinct and separate gradations. As you recall, all computer communication must be expressed in binary digits (or bits). And because a computer is binary, it is also digital. Thus, to be produced on a computer, sound and images must be con–verted into bits; it must cross the bridge from analog to digital.

Understanding the distinction between analog and digital signals is essential to grasping the challenges facing multimedia technology. Figure 10-2 illustrates the difference between using digital communication to describe the shape of a loading ramp and a staircase. A loading ramp is essentially analog because the changes in height of the ramp are gradual, continuous, with smooth transition, making the number of different heights of the loading ramp infinite. A staircase is essentially digital because changes in height move abruptly from one state to another, with no transition in between, in a way similar to counting. Figure 10-2 shows that it is easy to recreate the shape of the staircase because it is easy to measure the exact height of every part of the staircase, and there are a finite number of these heights. It is not so easy to recreate the shape of the loading ramp, because its height continuously gradually changes over the entire ramp. You can measure the height at any particular point of the ramp, but it is impossible to measure the height at every point of the ramp. Therefore, you are forced to measure the height at only some representative points. Measuring the heights at a series of representative points on the ramp in order to approximately reproduce the shape of the ramp is called **sampling**.
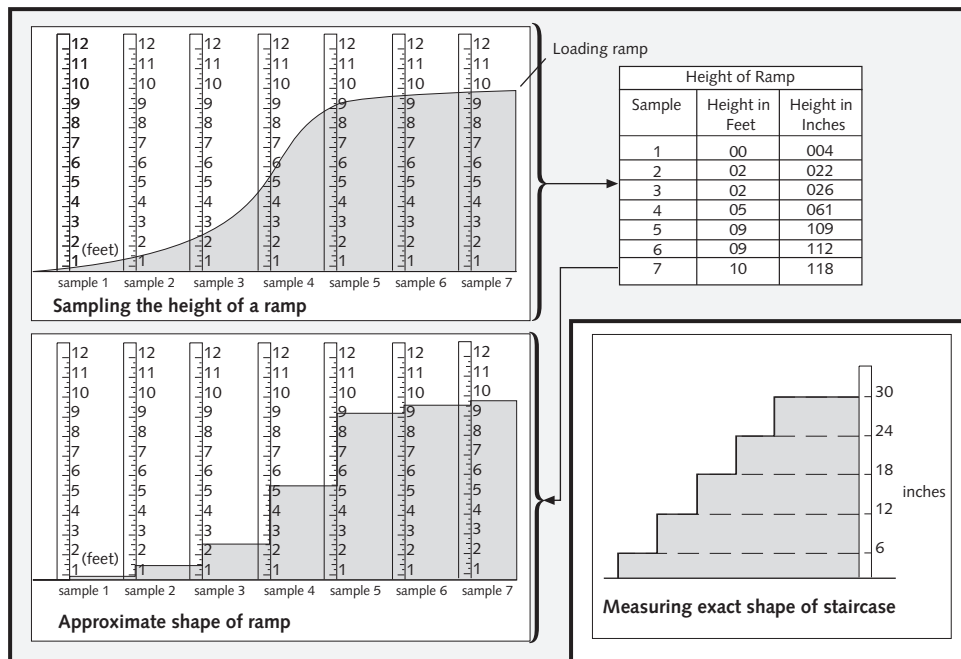
10

Figure 10-2   Expressing analog phenomena in digital terms is a challenge of multimedia

> **TIP**
> When analog data is converted to digital data for a PC, the data is sampled, meaning that samples are taken at discrete intervals and stored individually as digital data. This process is called digitizing the data, and the resulting data is an approximation of the original data.

Look at the sound wave in Figure 10-3a. To record and store this sound wave in a PC, to reproduce it as closely to its original analog nature as possible, you must first record the sound wave as numbers—that is, digitize the analog wave—because your PC can only store data that way (see Figure 10-4). To digitize the wave, first select how many samples you want to take (how frequently you will take a sample), how accurate your measurements will be, and how you will store these numbers. Later, you must follow the reverse process to retrieve these numbers and use them to reproduce a sound wave as close to the original as possible.

When digitizing the sound wave to produce the best possible reproduction, the more samples taken over a period of time and the more accurate each measurement, the more accurate the representation of the sound. However, there is a trade-off between the quality of a reproduction and the cost of the resources needed to create that reproduced sound. In other words, you need more resources both to store more samples and to store more accurate measurements of these samples, both of which lead to creating better sound. This trade-off is important in the multimedia world and drives many purchasing decisions.
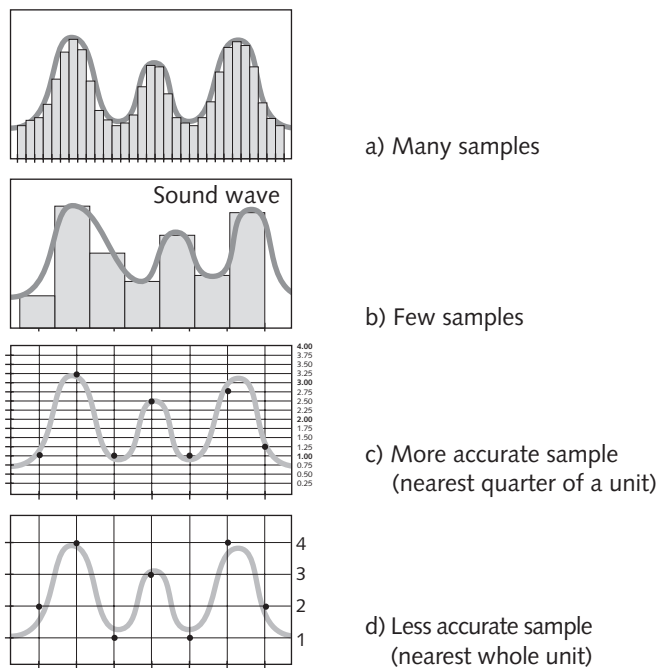
a) Many samples

b) Few samples

c) More accurate sample
   (nearest quarter of a unit)

d) Less accurate sample
   (nearest whole unit)

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Figure 10-3   Sampling a sound wave

Sound file (digital)

```
010011001011
011100111100
010111001011
010010000011
001011001011
110011001111
```
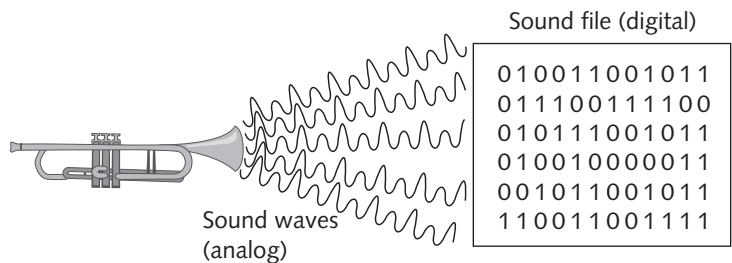
Sound waves
(analog)

Figure 10-4   Sound has analog properties, but sound files store sound digitally

To understand why more accurate measurements require more storage, look back at Figure 10-2. If you measure the ramp height to the nearest foot, you need to store only a two–digit number in the table of heights, because the highest point of the ramp is only 10 feet. The range of sampling values in feet is 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. If you choose to be more accurate, say to the nearest inch, then the range of sampling values increases to 0, 1, 2, 3, 4...120 inches, and the table must now hold three digits to store one number, which translates into a 50% increase in storage space to obtain greater accuracy. The number of samples and the accuracy of each sample determine the amount of storage needed to hold the values. The amount of storage needed to hold each measurement is called the **sample size**. However, you can use techniques to compress the data.

You need a compression method that does not lose too much information, and another method to decompress the values when you are ready to use them.

The impact of increasing measurement accuracy can be even greater in the binary world of the computer. Increasing the accuracy of the ramp measurement from feet to inches increased the storage space needed by 50% (from 2 digits for feet to 3 digits for inches). But remember that computers use bits instead of digits. So, 10 (feet) in binary is stored as 1010 (in 4 bits), but 120 inches is stored as 1111000 (7 bits) in binary. Since bits are stored in most multimedia files in even numbers of bits and not odd, measurements in feet would require 4-bit values, but measurements in inches would require 8-bit values, which creates a 100% increase in the storage requirement to gain added accuracy. In this chapter, look for the size in bits of the numeric values being stored as an indication of the accuracy of the data and the storage requirements.

In the two examples discussed above, the process is not very complicated, and the calculations are extremely easy. You just do the same thing many times, which is called "repetitive looping." However, you can see that the volume of data can get quite large when many samples are taken over a period of time.

> **TIP** There are basically two types of data processing: repetitive looping with high input/output volume used by multimedia technology, and computer-intensive data processing, which involves many and/or complex calculations and a relatively low volume of data. A CPU is designed to best support one type of data processing or the other.

As you study the remainder of the chapter, this model of measuring the height at selected points along a curve, storing these values in a list, and using them to approximately duplicate the original curve in digital terms is applied often. Multimedia applications vary in the methods they use to determine the type and number of samples, to digitize the samples, to compress the measurements, to decompress them later, and finally to reproduce the original analog entity, be it image or sound.

Early on, the multimedia industry tried to standardize hardware and software. In the early 90s, the Multimedia Marketing Council established the **MPC (Multimedia Personal Computer) guidelines**. Sponsored by the Software and Information Industry Association (SIIA), three levels of standards were developed, the last one being MPC3 released in 1996. Today, no standards organization has attained enough prominence in the marketplace to have an impact, resulting in many methods for capturing, compressing, storing and processing multimedia data. Also, the technology is improving at such a fast pace that a standard today is likely to be outdated tomorrow. For these reasons, look for new and different technologies emerging in the industry.

What CPU Technologies Do for Multimedia

Two enhancements by Intel to CPU technology designed with multimedia applications in mind are MMX, which is used by the Pentium MMX, Pentium Pro, and Pentium II, and SSE, which is used by the Pentium III. Multimedia software tends to use input/output operations

more than it performs complex computations. Both MMX and SSE were designed to speed up the repetitive looping of multimedia software manage the high-volume input/output of graphics, motion video, animation, and sound. MMX technology added three new architectural enhancements to the Pentium, all designed to speed up the repetitive looping of multimedia.

- **New instructions**. Intel added 57 new instructions to the CPU logic, all designed to handle the parallel, repetitive processing found in multimedia operations.

- **SIMD process**. A process called **single-instruction, multiple-data** (**SIMD**) was added that allows the CPU to execute a single instruction on multiple pieces of data rather than having to repetitively loop back to the previous instruction many times.

- **Increased cache**. Intel increased the size of the internal cache to 32K on the processor, reducing the number of times the CPU must access slower, off-chip memory for information.

The Pentium III introduced **SSE** (**streaming SIMD extension**), which is designed to improve the performance of high-end multimedia software. SSE can improve 3-D graphics, speech recognition, MPEG, and some scientific and engineering applications.

To compete with SSE, AMD introduced 3DNow!, a CPU instruction set that helps AMD processors perform better in 3D graphics and other multimedia data processing. 3Dfx, the manufacturer of the Voodoo graphics accelerator card, was the first hardware manufacturer to use the 3DNow! instruction set, although it is now being used by many hardware and software manufacturers.

To know that software or hardware is taking advantage of a CPU enhancement, look on the product package for the Intel MMX, Intel SSE, or 3DNow! symbols.

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DEVICES SUPPORTING MULTIMEDIA

Now that you have an understanding of the fundamentals of multimedia technology and insight into some of the early decisions made concerning hardware and software, you are ready to learn about several multimedia devices. This section looks at five popular multimedia devices: CD-ROM drives, sound cards, digital cameras, video capture cards, and Digital Video Disc (DVD) drives.

CD-ROM Drives

A+*CORE* *1.1* Of the multimedia components discussed in this chapter, the most popular is the CD-ROM drive. The technology of a CD-ROM drive is different from that of a hard drive, even though both are designed to hold data. CD-ROMs are popular media used to distribute software and sound files. CD-ROM drives are read-only devices. Read/writeable CD drives are discussed later in the chapter.

A+CORE 1.1 During the manufacturing process, data can be written to a CD-ROM disc only once, because the surface of the disc is actually embedded with the data. Figure 10-5 shows a CD-ROM surface that is laid out as one continuous spiral of sectors of equal length that hold equal amounts of data. The surface of a CD-ROM stores data as pits and lands. **Lands** are raised areas, and **pits** are recessed areas on the surface, each representing either a 1 or a 0, respectively. The bits are read by the drive with a laser beam that distinguishes between a pit and a land by the amount of deflection or scattering that occurs when the light beam hits the surface.
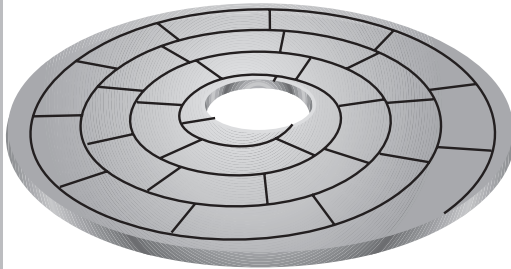
Figure 10-5   The spiral layout of sectors on a CD-ROM surface

A small motor with an actuator arm moves the laser beam to the sector on the track it needs to read. If the disc were spinning at a constant speed, the speed near the center of the disc would be greater than the speed at the outer edge. To create the effect of **constant linear velocity** (**CLV**), the CD-ROM drive uses a mechanism that speeds up the disc when the laser beam is near the center of the disc, and slows it down when the laser beam is near the outer edge so that the beam is over a sector for the same amount of time no matter where the sector is. (Since the outer edge has more sectors than the inner edge, the light beam needs more time to read near the outer edge than it does near the inner edge.) The transfer rate of the first CD-ROM drives was about 150K per second of data, with the rpm (revolutions per minute) set to 200 when the laser was near the center of the disc. This transfer rate was about right for audio CDs. To show video and motion without a choppy effect, the speed of the drives was increased to double speed (150K per sec 3 2), quad speed (150K per sec 3 4), and so on. It is not uncommon now to see CD-ROM drives with speeds at 40 times the audio speed. Audio CDs must still drop the speed to the original speed of 200 rpm and a transfer rate of 150K per second.

Because of the problems of changing speeds using CLV, newer, faster CD-ROM drives are using a combination of CLV and **constant angular velocity (CAV)**, the same technology used by hard drives, whereby the disc rotates at a constant speed.

When you choose a CD-ROM drive, look for the multisession feature that the drive to read a disc that has been created in multisessions. To say a disc was created in **multisessions** means that data was written to the disc at different times rather than in a single long, continuous session.

Some CD-ROM drives have power-saving features controlled by the device driver. For example, when the drive waits for a command for more than 5 minutes, it enters Power Save

Mode, causing the spindle motor to stop. The restart is automatic when the drive receives a command.

Caring for CD-ROM Drives and Discs

Most problems with CD-ROMs are caused by dust, fingerprints, scratches, defects on the surface of the CD, or random electrical noise. Don't use a CD-ROM drive if it is standing vertically, such as when someone turns a desktop PC case on its side to save desktop space. Use these precautions when handling CDs:

- Hold the CD by the edge; do not touch the bright side of the disc where data is stored.
- To remove dust or fingerprints, use a clean, soft, dry cloth.
- Do not write on, or paste paper to, the surface of the CD. Don't paste any labels to the top of the CD, because this can imbalance the CD and cause the drive to vibrate.
- Do not subject the CD to heat or leave it in direct sunlight.
- Do not use cleaners, alcohol, and the like on the CD.
- Do not make the center hole larger.
- Do not bend the CD.
- Do not drop the CD or subject it to shock.
- If a CD gets stuck in the drive, use the emergency eject hole to remove it. Turn off the power to the PC first. Then insert an instrument such as a straightened paper clip into the hole to manually eject the tray.

How a CD-ROM Drive Can Interface with the System Board

CD-ROM drives can interface with the system board in one of several ways. The drive can:

- Use an IDE interface; it can share an IDE connection and/or cable with a hard drive
- Use a SCSI interface with a SCSI host adapter
- Use a proprietary expansion card that works only with CD-ROMs from a particular manufacturer
- Use a proprietary connection on a sound card
- Be a portable drive and plug into an external port on your PC

Most CD-ROM drives are Plug and Play compliant. These drives allow a system to avoid resource conflicts. Boxes marked "Ready for Windows 95" or "Ready for Windows 98" indicate Plug and Play CD-ROM drives.

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$A^{+CORE}_{1.2}$ ## Installing a CD-ROM Drive

Installing a CD-ROM drive is easy, especially when the adapter is already present. If you are using a SCSI CD-ROM drive, install the host adapter or sound card first, and then install the drive. If you are using a proprietary adapter, install both at the same time. If you are using an existing IDE adapter card or connection on the system board, simply install the CD-ROM drive using an existing connection on the board or an extra connection on the hard drive data cable.

Figure 10-6 shows the front of a typical CD-ROM drive, and Figure 10-7 shows the rear view, where the power cord, data cable, sound cord, and ground connector attach. Also note that there is an "audio out" connection that supports a direct connection to a sound card. The jumper pins on a SCSI CD-ROM drive can:

- Control the SCSI ID for the drive
- Enable or disable SCSI parity checking
- Enable or disable the built-in SCSI terminator on the drive

The example shown is a SCSI CD-ROM drive. However, for IDE CD-ROM drives, expect to find jumpers that can set the drive as either the single drive, a slave drive, or the master drive in the IDE subsystem.
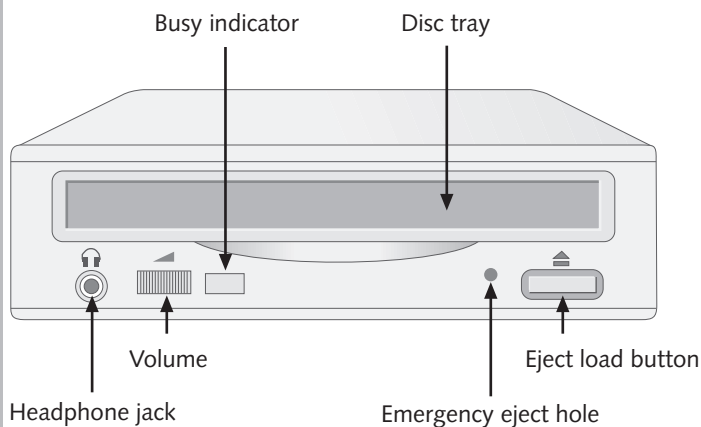
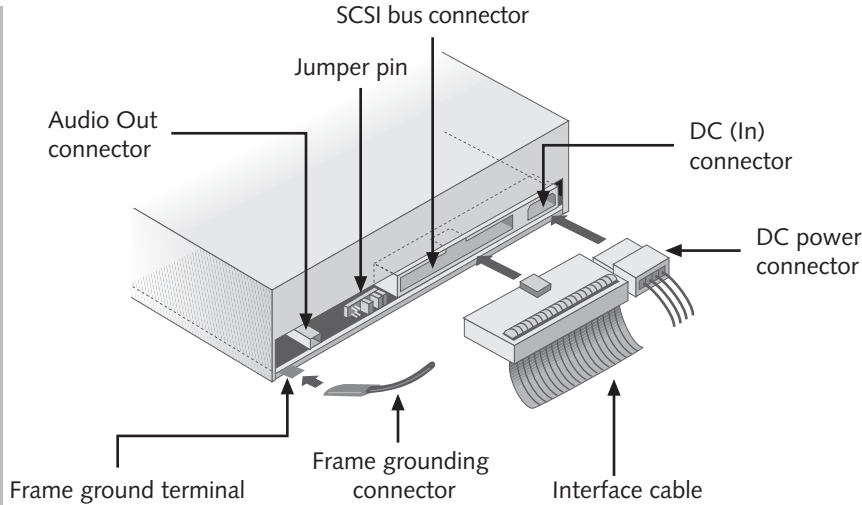**Figure 10-6**   Front view of a typical CD-ROM drive

Figure 10-7   Rear view of a typical SCSI CD-ROM drive showing drive connections

The CD-ROM drive documentation is your best installation guide, but here are a few general guidelines. The CD-ROM drive becomes another drive on your system, such as drive D or E. After it is installed, you access it just like any other drive by typing D: or E: at the DOS prompt, or by accessing the drive through Explorer in Windows 9x. The major differences are (1) the CD-ROM drive is read-only—you cannot write to it, (2) a CD-ROM is a little slower to access than a hard drive.

Configuring an IDE CD-ROM Drive

An IDE CD-ROM drive uses the **ATAPI** (Advanced Technology Attachment Packet Interface) standard, an extension of the IDE/ATA standard that allows tape drives and CD-ROM drives to be treated just like another hard drive on the system. With hard drives, IDE refers to the integrated drive electronics, but IDE as applied to a CD-ROM drive refers to the interface protocol between the drive and the CPU that requires software at the OS level to complete the interface. Windows 9x supports this protocol internally.

Figure 10-8 shows the rear of an IDE CD-ROM drive. Note the jumper bank that can be set to cable select, slave, or master. Recall from Chapter 7 that, for enhanced IDE, there are four choices for drive installations: primary master, primary slave, secondary master, and secondary slave. If the drive will be the second drive installed on the cable, then set the drive to slave. If the drive is the only drive on the cable, since single is not a choice, choose master.

When given the choice of putting the CD-ROM drive on the same cable with a hard drive or on its own cable, choose to use its own cable. If the CD-ROM drive shares a cable with a hard drive, it can slow down the hard drive's performance. Most systems today have two IDE connections on the system board, so most likely you will be able to use IDE2 for the CD-ROM drive.
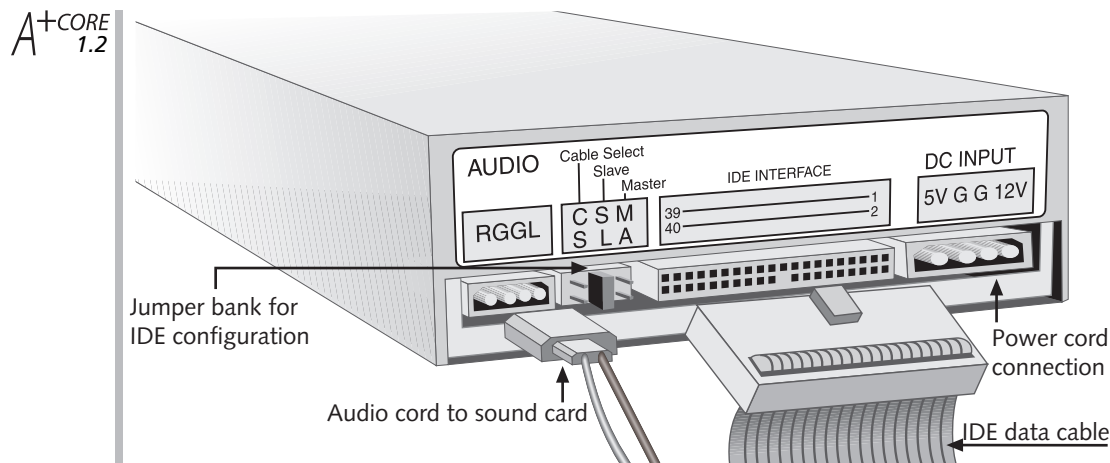
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$A^{+CORE}_{1.2}$

AUDIO
Cable Select
Slave
Master
IDE INTERFACE
DC INPUT

RGGL

C S M
S L A

39
40

1
2

5V G G 12V

Jumper bank for
IDE configuration

Audio cord to sound card

Power cord
connection

IDE data cable

Figure 10-8   Rear view of an IDE CD-ROM drive

Inserting the CD-ROM Drive

Some systems use rails on the drive to slide it into the bay. If you have them (the rails should come with your computer), screw the rails in place and slide the drive into the bay. If you have no rails, then put two screws on each side of the drive, tightening the screws so the drive can't shift, but avoiding overtightening them. Use the screws that come with the drive; screws too long can damage the drive. If necessary, buy a mounting kit to extend the sides of the drive so that it will fit into the bay and be securely attached.

Connect the Cables and Cords

Find an unused four-prong power cord from the power supply and plug it into the drive. For IDE drives, connect the 40-pin cable to the IDE adapter and the drive, being careful to follow the Pin 1 rule: match the edge color on the cable to Pin 1 on both the adapter card and the drive.

Some CD-ROM drives come with an audio cord that attaches the interface card to a sound card, which then receives sound input directly from the CD-ROM. Attach the audio cord if you have a sound card. Don't make the mistake of attaching a miniature power cord designed for a 3½-inch disk drive coming from the power supply to the audio input connector on the sound card. The connections appear to fit, but you'll probably destroy the drive by doing so.

Some drives have a ground connection, with one end of the ground cable attaching to the computer case. Follow the directions included with the drive.

Verify Power to the Drive

Check all connections, and turn on the power. Press the eject button on the front of the drive. If it works, then you know power is getting to the drive.

$A+^{CORE}_{1.2}$ ## Install the Device Driver for DOS

To operate in a DOS environment, a CD-ROM drive needs a device driver that is loaded from the CONFIG.SYS file. The driver interfaces with the drive and with a real-mode program called the Microsoft CD-ROM extension for DOS (MSCDEX.EXE), which must be loaded from AUTOEXEC.BAT. Both of these programs come on floppy disk with the CD-ROM drive. Run the installation program that is also on the disk. It copies the files to the hard drive and edits both the CONFIG.SYS and the AUTOEXEC.BAT files. Restart the computer so that the changes take effect. If you have problems accessing the drive after you have restarted, check the items listed under "Troubleshooting Guidelines," later in the chapter.

Install the Device Driver for Windows 9x

Windows 9x supports CD-ROM drives without add-on drivers. Click **Start**, **Settings**, **Control Panel**, and double-click **Add New Hardware**. Click **Next** when you are prompted to begin installing the software for the new device. Complete the installation by following the directions on the Add New Hardware sheet.

When Windows 9x starts up, it assigns the next available drive letter to the drive. To dictate what the drive letter should be, use Device Manager. Click **Start, Settings, Control Panel**, and select **System**. Click the **Device Manager** tab. Select the CD-ROM drive and click **Properties**, then the **Settings** tab (see Figure 10-9), where the drive is designated E:. Select a range of letters to be used by the drive and click **OK**.

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> **TIP** When you update or install additional features on applications software, some software expects the same drive letter for the CD-ROM drive that was used when it was first installed. Permanently setting the CD-ROM drive letter satisfies the requirements of this software.

Test the Drive

The drive is now ready to use. Press the eject button to open the drive shelf, and place a CD in the drive. Since data on CDs is written only on the bottom, be careful to protect it. Now access the CD using Explorer (use the assigned drive letter).

If you have a problem reading the CD, verify that the CD is placed in the tray label-side-up, and that the format is compatible with your drive. If one CD doesn't work, try another—the first CD may be defective or scratched.

A CD-ROM drive can be set so that when you insert a CD, software on the CD automatically executes, a feature called Autorun. To turn the feature on, from Device Manager, right click on the CD-ROM drive and select Properties. From the Properties window, select the Settings tab and select Auto insert notification. To prevent a CD from automatically playing when the feature is enabled, hold down the Shift key when inserting the CD.
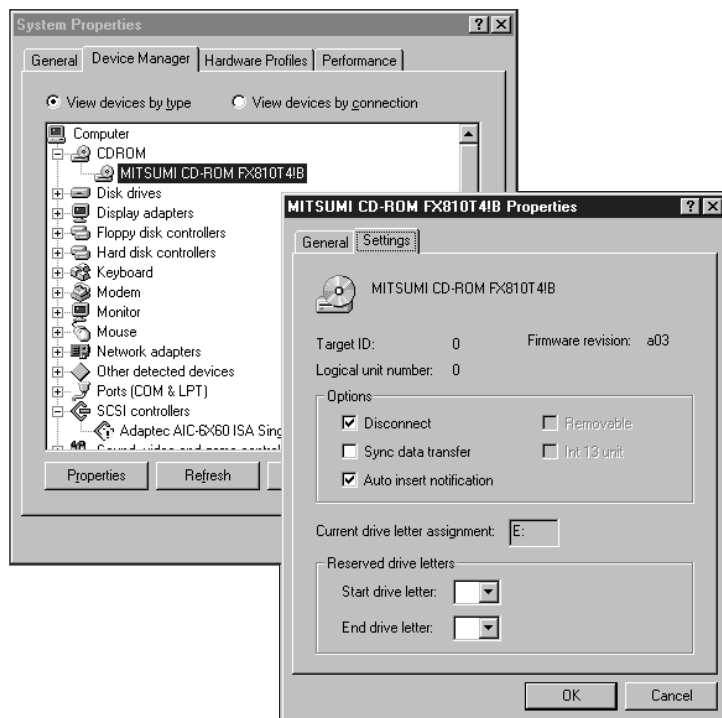
Figure 10-9   You can specify the drive letter assigned to the CD-ROM drive from the
Properties box for the drive

A^{+} OS
   1.1
Update Your Windows 95 Rescue Disk to Include Access to the CD-ROM Drive

The Windows 9x emergency startup disks you created in earlier chapters to start a system in the event of a hard drive failure need to include access to the CD-ROM drive, because Windows 9x is normally loaded from a CD-ROM. Windows 98 automatically adds the real-mode CD-ROM device drivers to this rescue disk, but Windows 95 does not. This section explains how to add this functionality to the rescue disk.

Windows 9x has its own built-in 32-bit protected-mode drivers for CD-ROM drives, but when booting from a rescue disk, you are using older 16-bit real-mode drivers. Two files are required, the 16-bit device driver provided by the manufacturer of the CD-ROM drive (or a generic real-mode driver that works with the drive) and the 16-bit real-mode OS inter-face to the driver, MSCDEX.EXE. The device driver is loaded from CONFIG.SYS, and MSCDEX.EXE is loaded from AUTOEXEC.BAT.

If you have run the DOS installation program that came with the CD-ROM drive, then your AUTOEXEC.BAT and CONFIG.SYS files should already have the correct entries in them. You can add these lines to these same files on your rescue disk, correcting paths to the two files as needed. Copy the two files to your rescue disk so you can access the CD-ROM drive when you boot from this disk, even when the hard drive is not accessible.

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For example, on a rescue or boot disk designed to access the CD-ROM drive without depending on any files or commands on the hard drive, the CONFIG.SYS file might contain this command (the parameters in the command lines are explained below):

```
DEVICE = SLCD.SYS /D:MSCD001
```

The AUTOEXEC.BAT file might contain this command line:

```
MSCDEX.EXE /D:MSCD001 /L:E /M:8
```

The explanations of these command lines are as follows:

- Two files needed to manage the drive are MSCDEX.EXE and SLCD.SYS, which must be copied to this disk.

- When the program MSCDEX.EXE executes, it uses the MSCD001 entry as a tag back to the CONFIG.SYS file to learn which device driver is being used to interface with the drive—in this case, SLCD.SYS.

- To MSCDEX.EXE, the drive is named MSCD001 and is being managed by the driver SLCD.

- MSCDEX.EXE will use SLCD as its "go-between" to access the drive.

- MSCDEX.EXE also assigns a drive letter to the drive. If you want to specify a certain drive letter, use the /L: option in the command line. In our example, the CD-ROM drive will be drive E. If you don't use the /L: option, then the next available drive letter is used.

- The /M: option controls the number of memory buffers.

- If the files referenced in these two commands are stored on the floppy disk in a different directory from the root directory, then include the path to the file in front of the filename.

If your hard drive fails and you start up from your rescue disk, once the CD-ROM drivers are loaded and the CD-ROM drive is recognized, you can install or reinstall Windows 9x from CD. To do this, insert the Windows 9x CD into the CD-ROM drive, and from the CD-ROM drive prompt (either D:, E: or some other letter), type **Setup** and then press **Enter**. Once Windows 9x is installed, it will often ignore existing CONFIG.SYS lines (turning them into comment lines by adding REM to the beginning of the line) and handle the CD-ROM drivers through its own protected-mode drivers.

Optimizing CD-ROM Cache

Recall that for Windows 9x, VCACHE replaced SmartDrive in Windows 3.x as the disk-caching software. For removable drives, VCACHE caches when reading data but not when writing. VCACHE decides how much memory to use when caching data, based on the speed of the CD-ROM drive and how much memory is installed in the system. You can affect this decision using the Performance tab in System Properties. Click **Start**, **Settings**, **Control Panel**, and select **System**. In the Properties dialog box, click the **Performance** tab and then click **File System**. Click **CD-ROM** on the File System Properties box, as seen

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in Figure 10-10. By changing the CD-ROM speed in this box, you are changing the amount of memory allotted to the cache. The amount is displayed in the last sentence on this box.
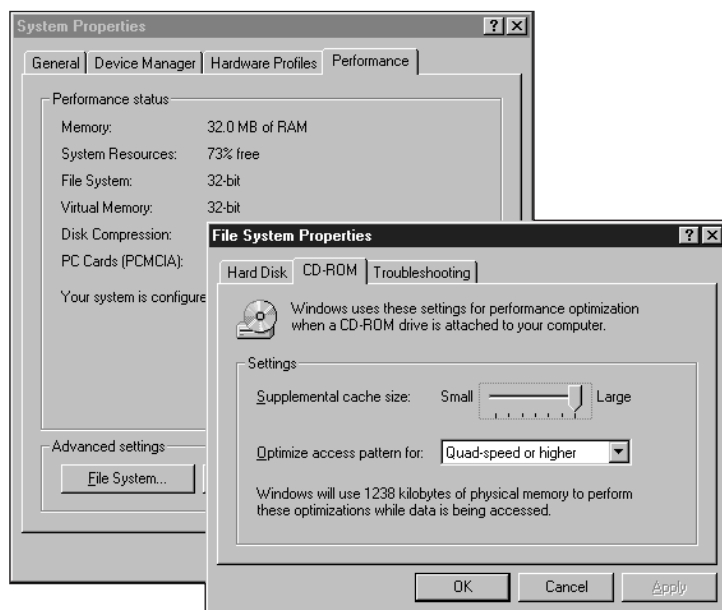

Figure 10-10   By changing the CD-ROM speed in the File System Properties box, you can change the amount of memory VCACHE uses

CD-R and CD-RW Drives

A CD-ROM is a read-only medium meaning that CD-ROM drives can only read, not write. In the past, writing to a CD required expensive equipment and was not practical for personal computer use. Now, **CD–Recordable** (**CD–R**) drives cost around $300, and the CD-R disc costs less than $5, making "burning" your own CD a viable option. These CD-R discs can be read by regular CD-ROM drives and are excellent ways to distribute software or large amounts of data. Besides allowing for a lot of data storage space on a relatively inexpensive medium, another advantage of distributing software and/or data on a CD–R disc is that you can be assured that no one will edit or overwrite what's written on the disc.

A regular CD-ROM is created by physically etching pits into the surface of the disc, but a CD–R disc is created differently. Heat is applied to special chemicals on the disc and causes these chemicals to reflect less light than the areas that are not burned, thus creating the same effect as a pit does on a regular CD. Referring to writing data to a CD-R as burning the CD-R is actually fairly accurate. When you purchase and install a CD-R drive, good software to manage the writing process is an important part of the purchase, because some less robust software can make burning a disc a difficult process. Also, some CD-R drives are multisession drives and some are not.

Also available at a higher cost is a **rewriteable CD** (**CD-RW**), which allows you to over-write old data with new data. The process of creating a CD-RW disc is similar to that used by CD-R discs. The chemicals on the surface of the CD-RW disc are different, allowing the process of writing a less-reflective spot to the surface of the disc to be reversed so that data can be erased. One drawback to these CD-RW discs is that the medium cannot always be read successfully by older CD-ROM drives.

CD-RW discs are useful in the process of developing CDs for distribution. A developer can create a disc, test for errors, and rewrite to the disc without having to waste many discs during the development process. Once the disc is fully tested, then CD-R discs can be burned for distribution. The advantages of distributing on CD-R discs rather than CD-RW discs are that CD-R discs are less expensive and can be read by all CD-ROM drives.

Sound Cards

A sound card is an expansion card that records sound, saves it to a file on your hard drive, and plays it back. Some cards give you the ability to mix and edit sound, and even to edit the sound using standard music score notation. Sound cards have ports for external stereo speakers and microphone input. Also, sound cards may be Sound Blaster compatible, which means that they can understand the commands sent to them that have been written for a Sound Blaster card, which is generally considered the standard for PC sound cards. Some play CD audio by way of a cable connecting the CD to the sound card. For good quality sound you definitely need external speakers and perhaps an amplifier.

Sound passes through three stages when it is computerized: (1) digitize or input the sound, that is, convert it from analog to digital, (2) store the digital data in a compressed data file, and later (3) reproduce or synthesize the sound (digital to analog). Each of these stages is discussed next, followed by a discussion of sound card installation.

Sampling and Digitizing the Sound

Remember that converting sound from analog to digital storage is done by first sampling the sound and then digitizing it. Sampling and digitizing the sound are done by a method called **pulse code modulation** (**PCM**) and involves a component called an **analog–to–digital converter** (**A/D** or **ADC**). It follows that the opposite technology, which converts digital to analog, is also needed, and that conversion is done by a **digital–to–analog converter** or **DAC**. The DAC technology on a sound card converts digital sound files back into analog sound just before output to the speakers.

When recording sound, the analog sound is converted to analog voltage by a microphone and is passed to the sound card, where it is digitized. As explained earlier in the chapter, the critical factor in the performance of a sound card is the accuracy of the samples (determined by the number of bits used to hold each sample value, which can be either 8 or 16 bits). This number of bits is called the **sample size**. The **sampling rate** of a sound card (the number of samples taken of the analog signal over a period of time) is usually expressed as samples (cycles) per second, or **hertz**. One thousand hertz (one kilohertz) is written as kHz. Remember that a low sampling rate provides a less accurate representation of the sound than

does a high sampling rate. Our ears detect up to about 22,000 samples per second or hertz. The sampling rate of music CDs is 44,100 Hz, or 44.1 kHz. When recording sound on a PC, the sampling rate is controlled by the software.

As explained above, sample size is the amount of space used to store a single sample measurement. The larger the sample size, the more accurate the sampling. The number of values used to measure sound is determined by the number of bits allocated to hold each number. If 8 bits are used to hold one number, then the sample range can be from -128 to +128. This is because 1111 1111 in binary equals 255 in decimal, which, together with zero, equals 256 values. Samples of sound are considered to be both positive and negative numbers, so the range is −128 to +127 rather than 0 to 255. However, if 16 bits are used to hold the range of numbers, then the sample range increases dramatically because 1111 1111 1111 1111 in binary is 65,535 in decimal, meaning that the sample size can be −32,768 to +32,767, or a total of 65,536 values.

An 8-bit sound card uses 8 bits to store a sample value, or uses a 256 sample size. A 16-bit sound card has a sample size of 65,536. Sound cards typically use 8- or 16-bit sample sizes, with a sampling rate from 4,000 to 44,000 samples per second. For high-quality sound, use a 16-bit sound card. Samples may also be recorded on a single channel (mono) or on two channels (stereo).

Don't confuse the sample size of 8 bits or 16 bits with the ISA bus size that the sound card uses to attach to the system board. A sound card may use an 8-bit sample size but a 16-bit ISA bus. When you hear people talk about an 8-bit sound card, they are speaking of the sample size, not the bus size.

Storing Sound in Files

Sound cards store sound in files in two ways: MIDI and WAV files. **MIDI** (**musical instrument digital interface**, pronounced "middy") technology, a standard for digitizing sound, dictates a specific number of sound samples and the quality of those samples. MIDI files have a .mid file extension. Nearly all sound cards support MIDI. The MIDI standard is supported by most synthesizers, so sounds created on one synthesizer can be played by another. Computers with a MIDI interface can receive sound created by a MIDI synthesizer and then manipulate the data in MIDI files to produce new sounds. The MIDI standards include storing sound data, such as a note's pitch, length, and volume, and can include attack and delay times. Data compression is used because sound files can be quite large.

Sampled files, which Microsoft calls **WAV** files (pronounced, and stands for, "wave"), have a .wav file extension. When Windows records sound using a sound card, the sound is stored in a .wav file. Most game music is stored in MIDI files, but most multimedia sound is stored in WAV files.

Sound files are often large. For example, CD-quality sound is recorded using a 16-bit sample size and 44.1 kHz sampling rate with stereo. The calculations of data size are:

16 bits $\times$ 44,100 samples/sec $\times$ 2 = 1,411,200 bits/sec or 176,400 bytes/sec

This yields more than 30 MB of disk space for a 3-minute song. Because of these large file sizes, methods of compressing data have evolved. Several are discussed next.

Compressing Data

You can compress data using several standards. Some apply to just audio and others to audio and video. To see the standards currently installed under Windows, double-click the **Multimedia** icon in Control Panel, and then click the **Devices** tab. See Figure 10-11. Click the plus sign next to **Audio Compression Codecs**. Compressing and later decompressing data is called **CODEC (Compressor/DECompressor)**. A CODEC method that does not drop any data is called **lossless compression**, and a method that works by dropping unnecessary data is called **lossy compression**. The term CODEC can also refer to hardware that converts audio or video signals from analog to digital or from digital to analog. When the term is used this way, it stands for coder/decoder.
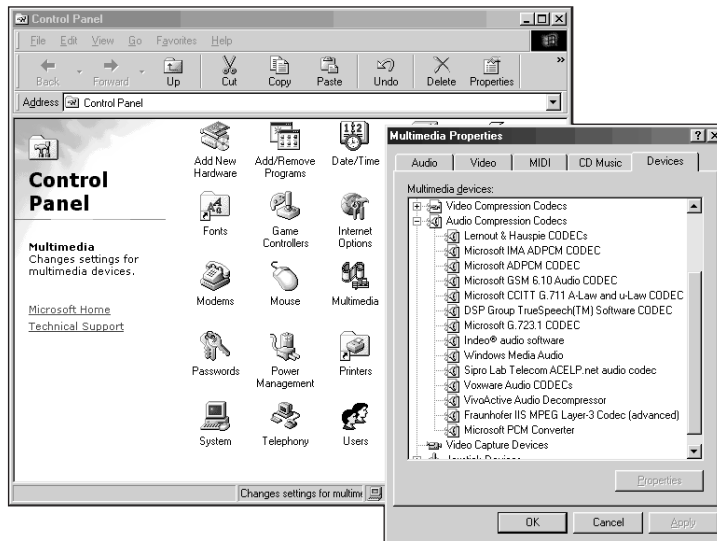

Figure 10-11   Use the Multimedia icon in Control Panel to see the codecs supported by Windows

One of the better-known data compression standards is MPEG, an international standard for data compression for motion pictures. Developed by the **Moving Pictures Experts Group** (**MPEG**), it tracks movement from one frame to the next, and only stores what changes, rather than compressing individual frames. MPEG is a type of lossy compression. MPEG compression can yield a compression ratio of 100:1 for full-motion video (30 frames per second, or 30 fps).

There are currently several MPEG standards, MPEG-1, MPEG-2, MPEG-3, and MPEG-4. MPEG-1 is used in business and home applications to compress images. MPEG-2 is used to compress video films on DVD-ROM. MPEG-3 is best known for audio compression. MPEG-4 is used for video transmissions over the Internet.

MPEG level 3 audio compression, better known as **MP3**, is a way to compress sound files to a compression ratio of 1:12 and even as low as 1:24 for stereo sound without losing sound quality. This compression is possible because the data is compressed in such a way that sound that is not normally heard or noticed by the human ear is cut out or drastically reduced. Sound files downloaded from the Internet are most often MP3 files. MP3 files have a .mp3 file extension. For more information about MPEG and MP3, see *www.mpeg.org*.

Digital-to-Analog Conversion

Sound cards use two methods to convert digitally stored sound into real analog sound: **FM (frequency modulation)** synthesis and **wavetable** synthesis. The difference between the two is that FM synthesis creates a sound by artificially creating a wave similar to the sound wave produced by the instrument. With FM synthesis, sound is reproduced by making a mathematical approximation of the musical sound wave. For example, the sound of a trumpet would be produced by imitating the sound wave produced by the trumpet, through a series of mathematical calculations. Wavetable synthesis produces the sound by using a sample recording of the real instrument. This table of stored sample sounds is called the wave table, and a group of samples for each instrument is called a **voice**. Wavetable synthesis produces better sound than does FM synthesis, but is also more expensive.

Sound Playback Once the sound has been converted back into an analog signal, you need speakers to play back the sound using a sound card. Unlike speakers used for other sound equipment, speakers made for computers have built-in amplifiers and extra shielding to protect the monitor from the magnetic fields around regular speakers.

> **TIP** If you plan to put speakers close to a monitor, be certain they are shielded. Speakers that are not shielded cause the monitor to display strange colors, and can eventually do permanent damage to the monitor. Also, setting floppy disks on top of unshielded speakers can damage the data on the disks.

$A^{+CORE}_{2.1}$ ‖ ### Installing a Sound Card and Software

Most sound cards come with a device driver as well as all the software needed for normal use, such as applications software to play music CDs. The installation of a sample sound card is described below. The sample card used is the Creative Lab's Sound Blaster PCI128 shown in Figure 10-12. It is Plug and Play compliant, uses a PCI slot, and supports a 128-voice wavetable. It will work under DOS 6+, Windows 9x, Windows NT, or Windows 2000. The card comes with drivers and software on a CD-ROM and a user's guide.
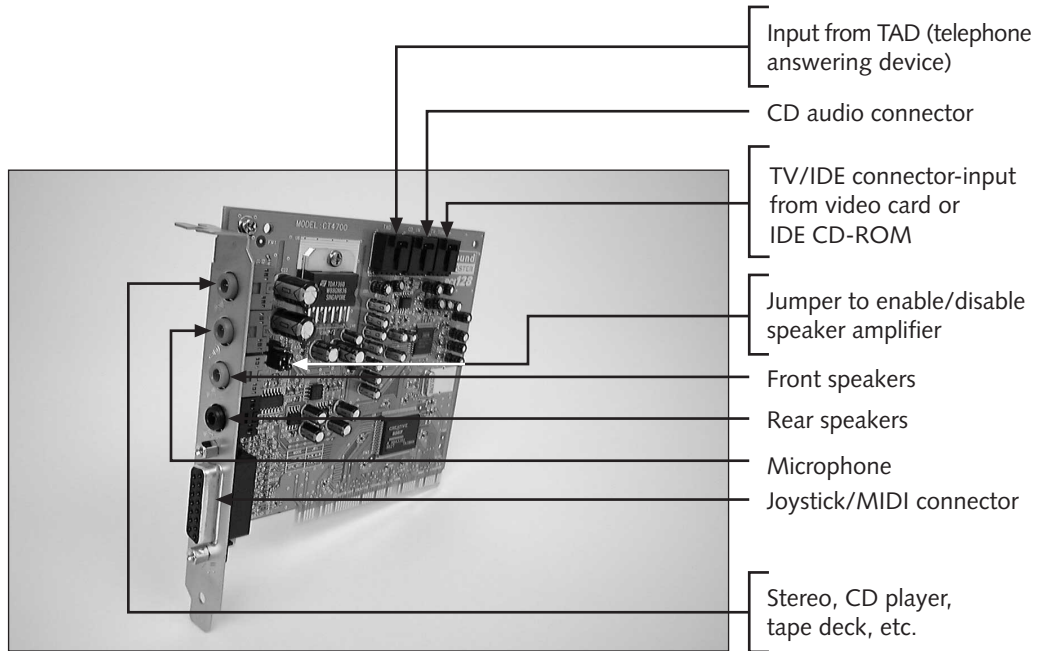
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Input from TAD (telephone answering device)

CD audio connector

TV/IDE connector-input from video card or IDE CD-ROM

Jumper to enable/disable speaker amplifier

Front speakers

Rear speakers

Microphone

Joystick/MIDI connector

Stereo, CD player, tape deck, etc.

Figure 10-12   A Sound Blaster sound card

The three main steps in this example of a sound card installation are to install the card itself in an empty PCI slot on the system board, install the driver under Windows 98, and then install the applications stored on the sound card's CD.

Installing a Sound Card   Follow these steps to install a sound card:

1. Turn the PC off, remove the cover, and locate an empty expansion slot for the card. Since this installation uses the connecting wire from the sound card to the CD-ROM drive (the wire comes with the sound card), place the sound card near enough to the CD-ROM drive so that the wire can reach between them.

2. Attach the wire to the sound card (see Figure 10–13) and to the CD-ROM drive.

3. Remove the cover from the slot opening at the rear of the PC case and place the card into the slot, making sure that the card is seated firmly. Use the screw taken from the slot cover to secure the card to the back of the PC case.

4. Check again that both ends of the wire are still securely connected, and replace the case cover.

5. Plug in the speakers to the ports at the back of the sound card and turn on the PC. The speakers may or may not require their own power source.
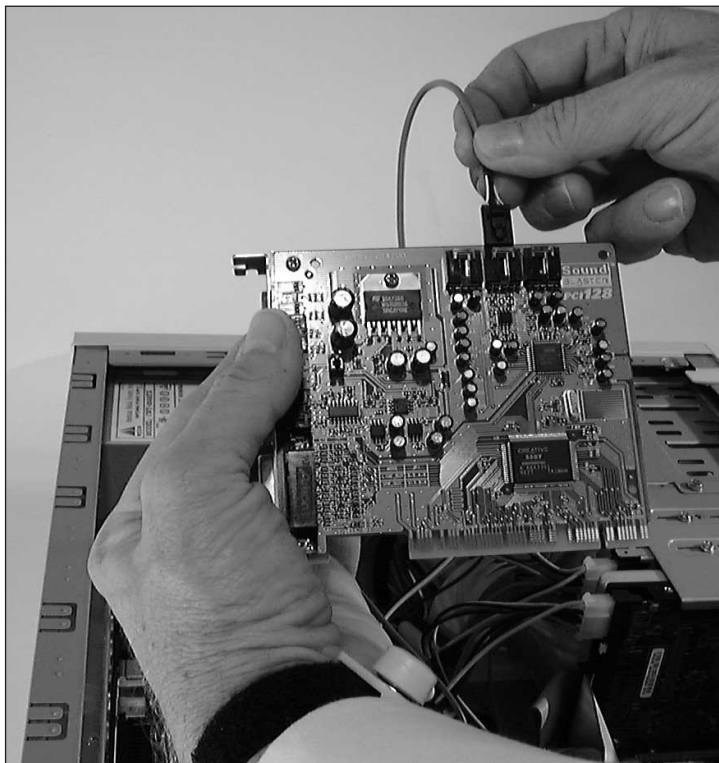
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Figure 10-13 Connect the wire to the sound card that will make the direct audio connection from the CD

Installing the Sound Card Driver Once the card is installed, the device drivers must be installed. When Windows 98 starts, it detects that new hardware is present. The New Hardware Found dialog box opens, indicating that it has discovered the Sound Blaster PIC128. Follow these steps to install the sound card driver:

1. The New Hardware Wizard gives you this option: **Search for the Best Driver for Your Device (Recommended)**. Select this option and click the **Next** button.

2. Clear all check boxes and check only the **Specify a Location** check box.

3. Click the **Browse** button and point to the driver path: **D:\Audio\English\Win95drv**.

   In this example, the CD-ROM drive is drive D, and the sound card's user guide listed the location of the driver on the CD. Substitute your CD-ROM drive letter and, for other sound card installations, see the documentation for the location of the driver on the CD-ROM.

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4. Click **Next** to continue the driver installation.

5. Click **Finish** when the installation is complete and reboot your PC.

With most sound cards, on the CD containing the sound card driver, you can find some special applications software to use the special features offered by the card. Sometimes, as is the case with this Sound Blaster card, this software is installed at the same time as the drivers so you can use the software at this point in the installation. With other sound cards, after the driver installation is complete and the sound card is working under Windows 9x, you can then install the additional software. See the documentation that comes with the sound card to learn if applications software is present and how and when to install it.

After you have installed the driver, rebooted, and entered Windows, verify that the device and the driver are correctly installed in Windows 98 by using Device Manager.

1. Click **Start**, point to **Settings**, click **Control Panel**, and then double-click **System**.

2. Select the **Device Manager** tab. Figure 10-14 shows the sound card installed.

3. To see the resources used by the card, select the card and click **Properties**. The Properties box displays. Click the **Resources** tab.
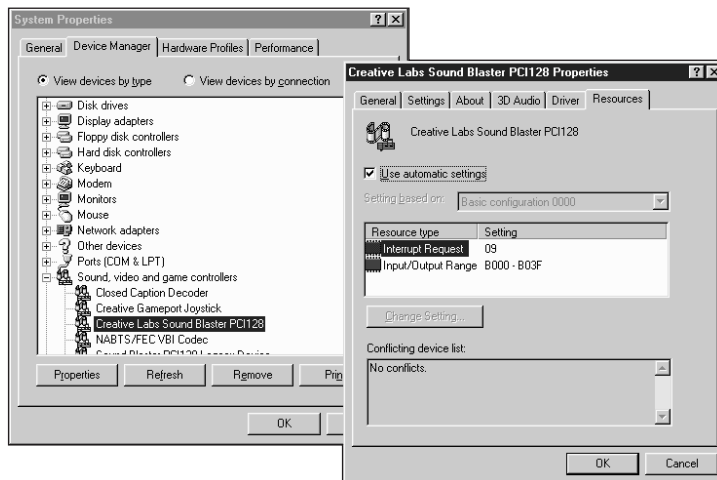
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Figure 10-14   Device Manager shows the sound card installed and the resources it is using

Using Sound with Windows 9x   Windows 9x offers some support for sound, such as playing a music CD or a WAV file or providing sound when performing certain Windows functions (such as starting an application or exiting Windows). This section will look at these features.

To configure the Windows 9x sound system to use the new sound card, first determine that sound control is installed under the Windows 9x Multimedia section, and then test the sound using Windows 9x:

1. Click **Start**, point to **Settings**, click **Control Panel**, and then double-click **Add/Remove Programs**.

2. Click the **Windows Setup** tab. From this tab, shown in Figure 10-15, you can install components of Windows 9x that were not installed at the original installation.
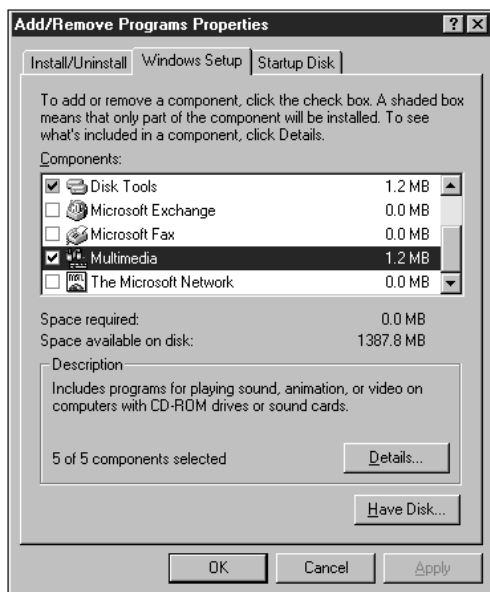

Figure 10-15 Windows 9x offers multimedia support

3. Click **Multimedia**, and then click **Details** to see the components of Windows 9x multimedia support (see Figure 10-16). Installed components are checked.

4. If CD Player, Volume Control, and Sound Recorder are not installed, then install them now. Select the files by clicking the check boxes.

5. Click **Apply** to install these components. You might be asked to insert the Windows 9x CD or floppy disks.

To test the sound, access the Multimedia group of Windows 95 or the Entertainment group of Windows 98. Note that the controls and windows displayed might be slightly different depending on the Windows 9x components, sound card drivers and other audio software installed:

1. For Windows 95, click **Start**, point to **Programs**, **Accessories**, and click **Multimedia**. For Windows 98, click **Start**, point to **Programs**, **Accessories**, and click **Entertainment**. Figure 10-17 shows the components for sound under Entertainment for Windows 98, which are the same for Windows 95 Multimedia.
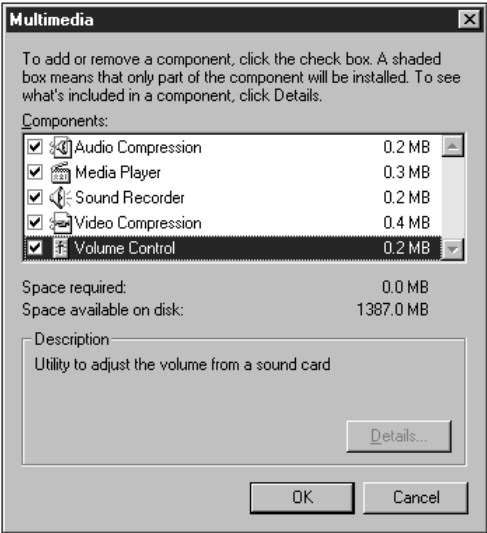
Figure 10-16   The components of Windows 9x multimedia support

Figure 10-17   Controlling sound using Windows 98

2. To play a music CD, click **CD Player**. The CD Player window is displayed. See Figure 10-18.

3. Insert a music CD in the CD-ROM drive and click the play button which is a forward arrow.

4. To adjust the volume of the sound card, click **Start**, point to **Programs**, **Accessories**, **Entertainment**, and click **Volume Control**. The Volume Control window in Figure 10-19 appears. Adjust the volume and close the dialog box when finished.

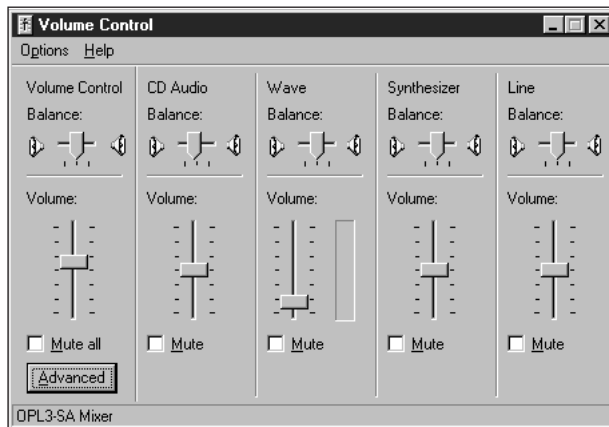**Figure 10-18**   Windows CD Player

Figure 10-19   Windows 9x volume control

A handy way to adjust the volume is to have Windows keep the volume control on the taskbar. To do this, use the Multimedia control in Control Panel: Click **Start**, **Settings**, **Control Panel** and then double-click **Multimedia**, and then click the **Audio** tab of the Multimedia window (see Figure 10-20). Check **Show volume control on the taskbar**.
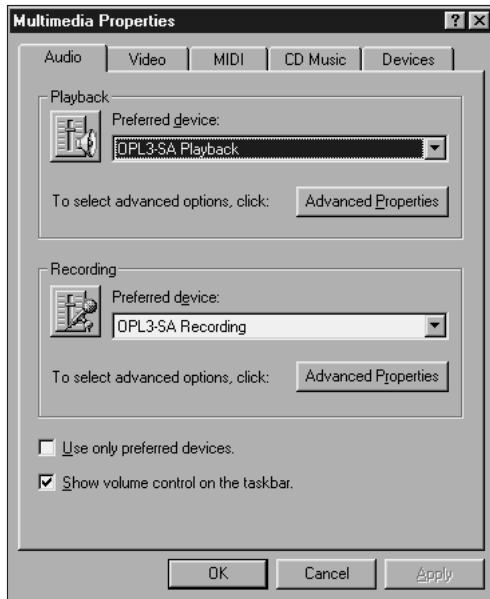
Figure 10-20   Windows 98 multimedia audio selection includes the option to put volume control on the taskbar

Recording Sound   In addition to being able to play sound, a multimedia system must be able to record it, for which you need a microphone. You can attach a microphone to the MIC port on the back of the sound card. Windows 9x saves sound files in the WAV file format. To record sound using Windows 9x, follow these steps:

1. Click **Start**, point to **Programs**, **Accessories**, **Multimedia (or Entertainment)**, and click **Sound Recorder** (see Figure 10-21).

Figure 10-21   Recording sound using Windows 9x

2. Click the **Record** button (the red dot on the right side of the dialog box) to record. Sound enters the microphone and moves as an analog signal to the sound card, which samples and digitizes it before passing it on to the CPU by way of the system bus.

3. Click the **Stop** button when finished recording.

4. Click **File** and **Save As** to save the sound file for later use.

Controlling Windows 9x Sounds   When certain events occur, Windows 9x plays sounds that are controlled by the Sounds control of the Windows 9x Control Panel. To customize these sounds and the times at which they occur, access Control Panel (click **Start**, **Settings**, **Control Panel**), and then double-click the **Sounds** icon. Items listed that have a horn icon beside them cause a sound. The sound for this item is defined in the Name list. For example, in Figure 10-22, for the event Exit Windows, the sound will be The Microsoft Sound.wav. To preview the sound, click the **Play** button to the right of the filename. You can develop your own customized choices of sounds for chosen events using this box. Save the scheme as a file using the **Save As** option at the bottom of the box, and use it to create a multimedia sound experience when working with Windows 9x!
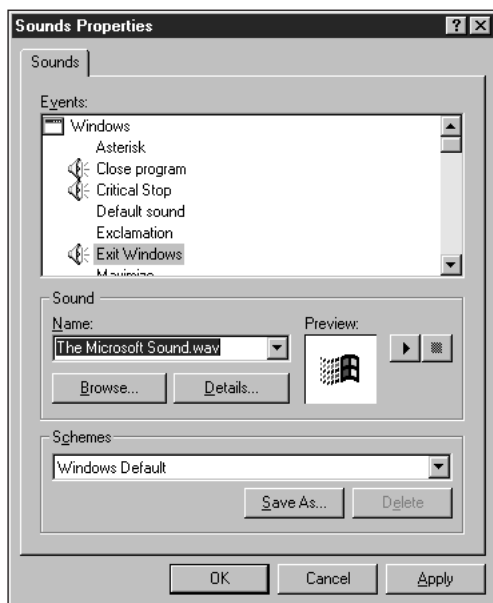

Figure 10-22   Controlling sound events under Windows 9x

Troubleshooting Guidelines

A^+ *CORE 2.2*   This section covers some troubleshooting guidelines for CD-ROM drives and sound cards.

Problems with a CD-ROM Installation

The following are general guidelines to use when a CD-ROM drive installation under DOS presents the problems described:

The Error Message "Invalid Drive Specification" Appears While the System Is Starting Up   Check that in the command lines in the CONFIG.SYS or AUTOEXEC.BAT files have no errors according to the documentation that came with the

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CD-ROM. Did you get an error message during startup, such as "Bad Command" or "File Not Found"?

Turn off the computer, reseat the adapter card, and check cable connections.

The MSCDEX.EXE program might not be loaded because it is placed too late in the AUTOEXEC.BAT file. Sometimes when an installation program edits the CONFIG.SYS or AUTOEXEC.BAT files, the command is added too late in the file. If AUTOEXEC.BAT has the command to load the CD-ROM program after the command to execute Windows, the CD-ROM command will not execute. If this is the case, move the command up near the beginning of the AUTOEXEC.BAT file.

You might be using a version of the MSCDEX.EXE program that is different from the version that comes with DOS. If you have DOS 6+, use the version of MSCDEX.EXE that is in the \DOS directory. Change the path to the command in AUTOEXEC.BAT so it accesses the DOS MSCDEX.EXE. For example, if the command line looks like this:

```
C:\CDROM\MSCDEX /D:MSCD001 /M:10
```

change it to read:

```
C:\DOS\MSCDEX /D:MSCD001 /M:10
```

The Install Process Is Terminated with the Message "MSCDEX.EXE Not Found"
MSCDEX.EXE must be copied onto the hard drive. Put it in the \DOS directory, then restart the install process. Sometimes MSCDEX is placed in the Windows directory, and sometimes a copy is put in the newly created CD-ROM directory.

The Error Message "Not Enough Drive Letters" Appears During the Startup Process
By default, DOS only allows five logical drive letters (A through E). If you have used these up, then you must tell DOS to accept more drive letters, with the LASTDRIVE line in CONFIG.SYS. The line can look like this:

```
LASTDRIVE=Z
```

Conflict Errors Exist   These appear during startup as error messages, or they can cause some other device to fail to operate. The IRQ and I/O address of your CD-ROM should be in the documentation. If not, call the manufacturer's technical support for this information or check the manufacturer's web site.

Computer does not recognize the CD-ROM drive (no D: prompt in DOS, or no drive D listed in Windows 9x Explorer)

- Check the data cable and power cord connections to the CD-ROM drive. Is the stripe on the data cable correctly aligned to pin 1? (Look for an arrow or small 1 printed on the drive. For a best guess, pin 1 is usually next to the power connector.)

- For an IDE drive, is the correct master/slave jumper set? For example, if both the hard drive and the CD-ROM drive are hooked up to the same ribbon cable, one must be set to master and the other to slave. If the CD-ROM drive is the only drive connected to the cable, then it must be set to single or master.

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- For an IDE drive, is the IDE connection on the system board disabled in CMOS setup?
- If you are using a SCSI drive, are the proper IDs set, and is the device terminated if it is the last item in the SCSI chain?
- If you are using DOS, check drivers including entries in CONFIG.SYS and AUTOEXEC.BAT, and verify that MSCDEX.EXE is in the correct directory.
- Is another device using the same port settings or IRQ number? For Windows 9x, see Control Panel, System, Device Manager.
- Suspect a boot virus. Run a virus scan program.

There is no sound Is the sound cable attached between the CD-ROM and the analog audio connector on the sound card?

- Are the speakers turned on?
- Is the speaker volume turned down?
- Are the speakers plugged into the line "Out" or the "Spkr" port of the sound card?
- Is the transformer for the speaker plugged into an electrical outlet on one end and into the speakers on the other end?
- Is the volume control for Windows turned down? (To check, click **Start**, **Programs**, **Accessories**, **Multimedia**, **Volume Control**.)
- Does the sound card have a "diagnose" file on the install disk?
- Reinstall the sound card drivers.
- Is another device using the same I/O addresses or IRQ number?
- To check for a bad connection, turn off the computer and remove and reinstall the sound card.
- Replace the sound card with one you know is good.

Digital Cameras

A recent introduction to multimedia, with markets in both business and home computing, is the digital camera, which is becoming more popular as quality improves and prices decrease. Digital camera technology works much like scanner technology, except that it is much faster. It essentially scans the field of image set by the picture taker, and translates the light signals into digital values, which can be stored as a file and viewed with software that interprets the stored values appropriately.

TWAIN (technology without an interesting name) format is a standard format used by both digital cameras and PCs for transferring the image. Transfer the image to your computer's hard drive using a serial cable supplied with the camera, a parallel cable, or some external disk medium such as a flash RAM card, which is faster and more convenient than the other methods. Figure 10-23 shows a SmartMedia card from a digital camera inserted into a FlashPath card that can then be inserted into a floppy disk drive to upload images to the PC.
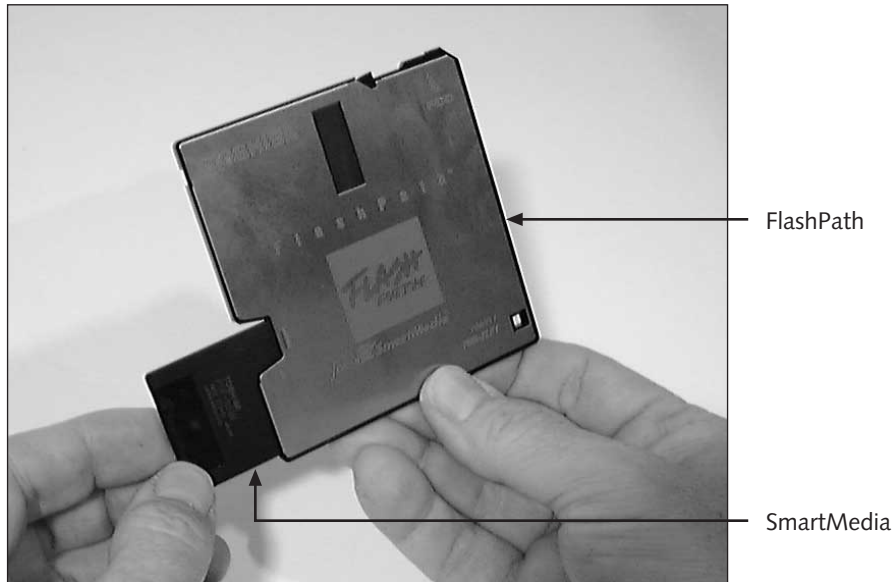
Figure 10-23 The small SmartMedia card holds the digital images from a digital camera. FlashPath allows a PC to read SmartMedia by way of a floppy disk drive

Once the images are on the PC, use the camera's image-editing software or another program such as Adobe PhotoShop to view, touch up, and print the picture. The picture file, which is usually in **JPEG** (**Joint Photographic Experts Group**) format, can then be imported into documents. JPEG is a common lossy compression standard for storing photos.

Most digital cameras also have a video-out port so that you can attach the camera to any TV using a serial cable. You can then display pictures on TV or copy them to videotape.

The image sensing can be done by two kinds of technology: infrared sensor or charge-coupled device (CCD). The image sensor captures light reflected off the subject and converts that light to a serial stream of small DC voltages. The image sensor is made up of three sensors, each filtering a different color (red, green, or blue). Figure 10-24 shows the process a digital camera uses to create a picture. The figure shows only one channel of the three channels used (one channel for each color). The image sensor captures the light and converts it into voltage signals that will become pixels. These signals move through the DC restore or DC clamping stage and then on to the gain stage, where the signals are amplified and buffered. Next, the signals enter the ADC (analog-to-digital converter), where they are digitized. The digital pixels are then processed by the image processor and sent on to storage through the I/O process. The controller in the diagram controls all processing of the digital signals.
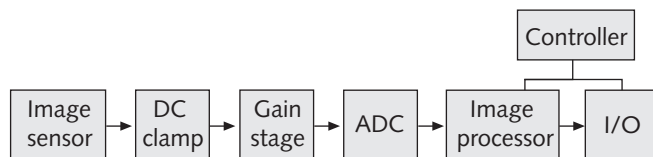
Figure 10-24   The signal chain used by a digital camera

MP3 Player

A popular audio compression codec is MP3, an advanced method of MPEG-3, that can reduce the size of a sound file as much as 1:17 without a noticeable loss in quality. An MP3 player is a device or software that plays these MP3 files. Portable MP3 players store the MP3 files on a compact storage device such as a SmartMedia card by Toshiba. When using a digital camera, data is transferred or uploaded from the camera to the PC, but when using a portable MP3 player, data is downloaded from the PC to the player.

You can purchase MP3 music files on the storage media suitable for your MP3 player, from regular CDs, or from web sites on the Internet such as eMusic at *www.emusic.com*. From the Internet, download them to your PC and then either play them on your PC using MP3 player software such as Windows Media Player or MusicMatch Jukebox (see *www.musicmatch.com)*. You can also play the MP3 files directly from the Internet without first downloading them, which is called **streaming audio**.

Traditional music CDs store music files in CD format. You can use software that copies the music file from the CD and converts it to a WAV file, which is not compressed. This software is called a ripper because you're "ripping off" the CD. Once the file is in WAV format on your hard drive, use encoder software to compress the file into MP3 format. Next copy the MP3 file to a SmartMedia card or other type of flash storage device. For example, I-Jam portable MP3 players use a flash card smaller than SmartMedia called SanDisk. Data is downloaded to the card by way of a serial port interface. For more information about I-Jam MP3 players, see *www.ijamworld.com* and for information about the SanDisk flash card, see *www.sandisk.com*. CD rippers, MP3 encoders, and MP3 player software can be downloaded from the Internet. For example, see the MusicMatch site at *www.musicmatch.com*.

Video-Capturing Card

An NTSC (National Television Standards Committee) video-capturing card is another multimedia option. With this card, you can capture input from a camcorder or directly from TV. Video can be saved as motion clips or stills, edited, and, with the right card, copied back to video tape for viewing by a VCR and television. Look for these features on a video capture card: an IEEE 1394 port to interface with a digital camcorder, data transfer rates which affect the price of the card, capture resolution and color-depth capabilities of the card, ability to transfer data back to the digital camcorder or VCR, stereo audio jacks, and the video editing software bundled with the card. Other options include a TV tuner which makes it possible to turn your PC into a television complete with instant replay and program scheduling. Ports on a video capturing card might include an antenna or cable TV port for input and a TV or VCR

port for output. Other ports are a PC monitor video port and possibly an IEEE 1394 port for a camcorder. Expect the card to fit into an AGP slot and take the place of your regular video card. For an excellent example of a video capturing card, see the All-in-Wonder card from ATI Technologies at *www.ati.com*.

Digital Video Disc (DVD)

With multimedia, the ability to store massive amounts of data is paramount to the technology's success. The goal of storing a full-length movie on a single unit of computerized, inexpensive storage medium has been met by more than one technology, but the technology that has clearly taken the lead in popularity is **digital video disc**, or digital versatile disc (**DVD**) technology (see Figure 10-25). It takes up to seven CDs to store a full-length movie, and only one DVD disc. A DVD disc can hold 8.5 GB of data, and, if both the top and bottom surfaces are used, can hold 17 GB of data, which is enough for more than 8 hours of video storage.

Figure 10-25   A DVD device

Both DVD and CD-ROM technologies use patterns of tiny pits on the surface of a disc to represent bits, which are then readable by a laser beam. When looking at the surface of either disc, it is difficult to distinguish between the two. They both have the same 5-inch diameter and 1.2-mm thickness, and the same shiny surface. But, because DVD uses a shorter wavelength laser, it can read smaller, more densely packed pits, which increases the disc's capacity. In addition, there is a second layer added to DVD discs, an opaque layer that also holds data, which almost doubles the capacity of the disc. Also, a DVD disc can use both the top and bottom surface for data.

DVD uses MPEG-2 video compression and requires an MPEG-2 controller card to decode the compressed data. Audio is stored on DVD in Dolby AC-3 compression. This audio compression method is also the standard to be used by HDTV (high-definition TV), soon to be introduced into the marketplace. Dolby AC-3 compression is also known as Dolby Digital Surround or Dolby Surround Sound and supports six separate sound channels of sound information for six different speakers, each producing a different sound! These speakers are known as Front Left and Right, Front Center, Rear Left and Right, and Subwoofer. Because each channel is digital, there is no background noise on the channel, and a sound engineer can place sound on any one of these speakers. The sound effects can be awesome!

The DVD controller card decodes both MPEG-2 video and Dolby AC-3 audio data and outputs them to a video port and speaker port, respectively. This PCI controller card can be configured to work in more than one way. Figure 10-26 shows one configuration demonstrating how the flow of data can come from a DVD disc through the PC to speakers and monitor. The DVD drive is attached to the system board by way of a SCSI controller that enables the data to bypass the CPU and to be routed directly to the MPEG-2 decoder card. The MPEG-2 decoder separates the video data from the sound data, decodes both, and sends the video data to the video controller card and on to the monitor. The DVD controller is also acting as a sound card. The sound data is sent to a DAC on the card that directs the analog sound signal to the speakers.
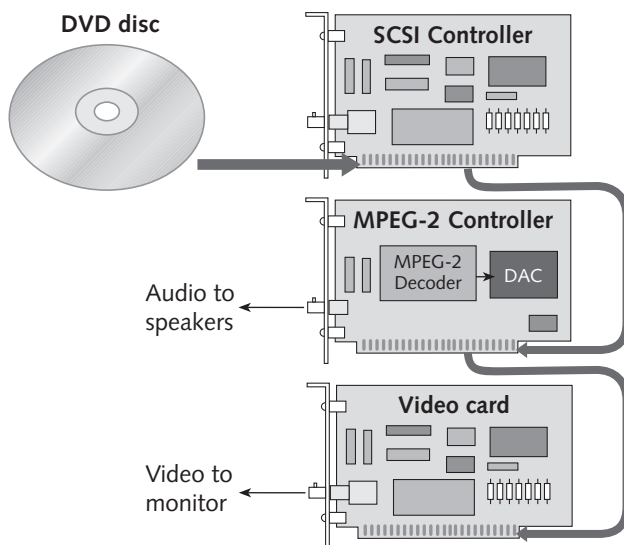

Figure 10-26 How a PC can use DVD data

Other DVD Devices

Besides DVD ROM, new DVD devices are coming on the market that are read-writeable. Table 10-1 describes these devices.

Table 10-1   DVD devices

DVD Device	Description
DVD-ROM	Read-only device. A DVD-ROM drive can also read CD-ROMs.
DVD-R	DVD recordable. Uses a similar technology to that used by CD-R drives. Holds about 4.7 GB of data. Can read DVD-ROM discs.
DVD-RAM	Recordable and erasable. Multifunctional DVD device that uses phase-dual (PD) technology. Can read DVD-RAM, DVD-R, DVD-ROM, and CD-R discs.
DVD-RW or DVD-ER	Rewritable DVD device, also known as erasable, recordable device. Uses phase-dual technology. Media can be read by most DVD-ROM drives.
DVD+RW	A technology similar to and currently competing with DVD-RW. Can read DVD-ROM and CD-ROM discs, but will not be compatible with DVD-RAM discs.

The last three items in Table 10-1 are competing with one another. All have similar, yet different, features, and compatibility and standards are issues. It's yet to be seen which of these three media will prevail in the marketplace. When purchasing one, pay close attention to compatibility with other media, such as CD-ROM, and availability and price of discs.

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CHAPTER SUMMARY

❑ Multimedia PCs and devices are designed to create and reproduce lifelike presentations of sight and sound.

❑ Magazines, books, the Internet, retailers, and satisfied users are excellent resources for information when you are looking into purchasing multimedia devices.

❑ MPEG is a lossy compression method for files storing full-motion video and sound; lossy compression refers to compressing data by eliminating some of the data.

❑ MP3 is a version of MPEG compression used for audio files. Portable MP3 players stored MP3 files on flash storage devices.

❑ When analog data is converted to digital data for a PC, the data is sampled, meaning that samples are taken at discrete intervals and stored individually as digital data. This process is called digitizing the data, and the results are an approximation of the original data.

❑ When converting from analog to digital, the greater the number of samples and the more accurate each sample, the better the approximation of the original analog data.

❑ Interpolative scaling and color space conversions are two methods used by video controllers to improve video output.

❑ MIDI is a standard for the transmitting and storage of synthesized sound and is used by many sound cards.

❑ A sound card uses pulse code modulation or PCM, which is a sampling method, to convert analog sound to digital.

❐ Two methods of synthesizing sound are FM and wavetable. The wavetable method is more expensive and more accurate than FM.

❐ MMX and SSE by Intel and 3DNow! by AMD improve the speed of processing graphics, video, and sound, using improved methods of handling high-volume repetition during I/O operations.

❐ In order to take full advantage of MMX, SSE, or 3DNow! technology, software must be written to use its specific capabilities.

❐ CD-ROMs are read-only devices with data physically embedded into the surface of the disc.

❐ The speed of some CD-ROM drives slows down as the laser beam moves from the inside to the outside of the disc.

❐ CD-ROM drives can have an IDE or SCSI interface, or they can connect to the system bus through a proprietary expansion card or through a connection on a sound card.

❐ The most common interface for CD-ROM drives is IDE, which uses the ATAPI standard, an extension of the IDE/ATA standard developed for tape drives and CD-ROM, so that they can be treated just like another drive on the system.

❐ Data is only written to the bottom of a CD-ROM, which should be protected from damage.

❐ If you have installed Windows 95 from CD, be sure that your Windows 95 emergency startup disk has the necessary real-mode drivers on it to support a CD-ROM drive when this disk is used as the boot device. Windows 98 normally puts these drivers on the rescue disk for you.

❐ Installing a sound card includes physically installing the card, then installing the sound card driver and sound applications software. Windows 9x supports multimedia sound without using other applications software, but applications that usually come with sound cards enhance the ability to control various sound features.

❐ Digital cameras use light sensors to detect light and convert it to a digital signal stored in an image file using JPEG format.

❐ A DVD can store a full-length movie and uses an accompanying decoder card to decode the MPEG-compressed video data and Dolby AC-3 compressed audio.

❐ Video capture cards can be used to capture video images from VCRs, camcorders, and TVs for storage and manipulation on your PC.

KEY TERMS

Analog-to-digital converter (**A/D** or **ADC**) — A component on a sound card that samples and converts analog sound into digital values that can be stored on hard drives.

ATAPI (**Advanced Technology Attachment Packet Interface**) — An interface standard that is part of the IDE/ATA standards, which allows tape drives and CD-ROM drives to be treated like an IDE hard drive by the OS.

Bit map file — A type of graphics file in which the image is written as a series of 0s and 1s. These files have the extension .bmp and can be loaded into paint programs to be edited and printed.

CD–R (**recordable CD**) — A CD drive that can record or write data to a CD. The drive may or may not be multisession, but the data cannot be erased once it is written.

CD–RW (**rewriteable CD**) — A CD drive that can record or write data to a CD. The data can be erased and overwritten. The drive may or may not be multisession.

CODEC (**compressor/decompressor**) — Compressing and later decompressing sound, animation, and video files. MPEG is a common example. Also stands for coder/decoder when referring to digital-to-analog conversions.

Constant angular velocity (CAV) — A technology used by hard drives and newer CD-ROM drives whereby the disc rotates at a constant speed.

Constant linear velocity (**CLV**) — A CD-ROM format in which the spacing of data is consistent on the CD, but the speed of the disc varies depending on whether the data is reading near the center or the edge of the disc.

DAC (**digital–to–analog converter**) — A component that converts digital data back into analog signals just before output from the computer. For example, DAC technology is used to convert digital sound to analog sound just before playback to the speakers.

Digital video disc (**DVD**) — A faster, larger CD-ROM format that can read older CDs, store over 8 gigabytes of data, and hold full-length motion picture videos.

FM (**frequency modulation**) **method** — A method of synthesizing sound by making a mathematical approximation of the musical sound wave. MIDI may use FM synthesis or wavetable synthesis.

Hertz (**Hz**) — Unit of measurement for frequency, calculated in terms of vibrations, or cycles, per second. For example, a Pentium CPU may have a speed of 233 MHz (megahertz). For 16-bit stereo sound, 44,100 Hz is used.

JPEG (**Joint Photographic Experts Group**) — A "lossy" graphical compression scheme that allows the user to control the amount of data that is averaged and sacrificed as file size is reduced. It is a common Internet file format. *See* Lossy compression.

Land — Microscopic flat areas on the surface of a CD or DVD that separate pits. Lands and pits are used to represent data on the disc.

Lossless compression — A method that substitutes special characters for repeating patterns without image degradation. A substitution table is used to restore the compressed image to its original form. *See* Lossy compression.

Lossy compression — A method that drops unnecessary data, but with some image and sound loss. JPEG allows the user to control the amount of loss, which is inversely related to the image size. *See* Lossless compression.

MIDI (Musical Instrument Digital Interface) — Pronounced "middy," a standard for transmitting sound from musical devices, such as electronic keyboards, to computers where it can be digitally stored.

MMX (**Multimedia Extensions**) **technology** — A variation of the Pentium processor designed to manage and speed up high-volume input/output needed for graphics, motion video, animation, and sound.

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MP3 — A method to compress audio files that uses MPEG level 3. It can reduce sound files as low as a 1:24 ratio without loosing sound quality.

MPEG (**Moving Pictures Experts Group**) — A processing-intensive standard for data compression for motion pictures that tracks movement from one frame to the next, and only stores the new data that has changed.

Multimedia — A type of computer presentation that combines text, graphics, animation, photos, sound, and/or full-motion video.

Multisession — A feature that allows data to be read (or written) on a CD during more than one session. This is important if the disc was only partially filled during the first write.

Pit — Recessed areas on the surface of a CD or DVD, separating lands, or flat areas. Lands and pits are used to represent data on the disc.

Pulse code modulation (**PCM**) — A method of sampling sound in a reduced, digitized format, by recording differences between successive digital samples instead of their full values.

Sample size — Refers to samples taken when converting a signal from analog to digital. Sample size is a measure of the amount of storage allocated to a single measurement of a single sample. The larger the sample size, the more accurate the value and the larger the file sizes needed to store the data.

Sampling — Part of the process of converting sound or video from analog to digital format, whereby a sound wave or image is measured at uniform time intervals and saved as a series of smaller representative blocks. *See* Sampling rate.

Sampling rate — The rate of samples taken of an analog signal over a period of time, usually expressed as samples per second, or Hertz. For example, 44,100 Hz is the sampling rate used for 16-bit stereo.

Single-instruction, multiple-data (**SIMD**) — An MMX process that allows the CPU to execute a single instruction simultaneously on multiple pieces of data rather than by repetitive looping.

SSE (**streaming SIMD extension**) — A technology used by the Intel Pentium III designed to improve performance of multimedia software.

Streaming audio — Downloading audio data from the Internet in a continuous stream of data without first downloading an entire audio file.

Voice — A group of samples for a musical instrument stored in a wavetable.

Wavetable — A table of stored sample sounds used to synthesize sound by reconstructing the sound from digital data using actual samples of sounds from real instruments.

REVIEW QUESTIONS

1. Describe the methodology used to convert analog data into digital data.
2. What two factors determine how accurately digital data represents analog data?
3. MPEG is used to compress what type of data? Describe the compression technique.
4. Typically, how many frames per second are displayed with MPEG?

5. What term refers to the standard interface for computers to electronic sound devices, such as musical keyboards?

6. Compare a DAC to an ADC. Where would you expect to find either of these components?

7. Compare the two methods to synthesize sound, wavetable and FM.

8. What must be true before MMX, SSE, and 3DNow! technology can improve multimedia performance on a PC?

9. Compare the speed of a hard drive platter turning on the spindle to the speed of a CD-ROM.

10. Name three ways a CD-ROM drive can interface with a system board.

11. Which side of a CD contains data?

12. If a CD-ROM drive and a hard drive are sharing the same data cable in a computer system, what type of connection is the CD-ROM drive using? Which of the two drives should be set to master? Which to slave?

13. When you are installing a CD-ROM drive, what is the solution when the DOS error message at startup reads, "Not enough drive letters"?

14. How do you access the volume control under Windows 9x for sound?

15. What is the difference between a CD-R drive and a CD-RW drive?

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16. What hardware device that is a field replaceable unit converts sound from analog to digital?

17. When sound is digitized, what is the number of bits to hold each sample called?

18. The purpose of a microphone is to convert _____ sound to _____ voltage, which is then passed to a sound card.

19. What unit of measure is used to express the sampling rate of a sound card?

20. Sound samples recorded on a single channel are called _____, on two channels are called _____, and on six channels are called _____.

21. What is the sampling rate (in Hz) of music CDs?

22. What are the two most common file extensions for uncompressed sound files?

23. What effect could unshielded or very large speakers have on a monitor if they were placed too close to the monitor?

24. What would be a quick, short test to see if a sound card was successfully installed?

25. List several common file extensions used with graphics files.

26. For each of the following pairs, state which item is analog and which is digital:

    a. Text stored on a floppy disk, handwritten note

    b. MIDI file, sound

    c. Monitor display, video memory

    d. A loading ramp, a flight of stairs

    e. A serial cable, a telephone line

27. In Windows 95, sound controls are under the _____ option of Accessories, but in Windows 98, the controls are under the _____ option of Accessories.

28. Describe the purposes of FlashPath and SmartMedia technology.

29. What two things does a DVD controller decode? What compression methods are used for both?

30. What is the size of an uncompressed audio file that contains 3 minutes of music captured using CD-quality sound?

PROJECTS

Preparing for a Windows 95 Crash

Suppose you have Windows 95 stored on a CD-ROM and you don't have it stored on floppy disks. Your hard drive fails, or for some other reason Windows 95 on your hard drive will not load. How do you recover Windows 95 from the CD-ROM if the only way to access the CD is through Windows 95 on the hard drive? Prepare a recovery disk with which you can do these things:

a. Boot from the disk to a command prompt

b. Access the CD-ROM drive without using the hard drive

Include on the disk AUTOEXEC.BAT and CONFIG.SYS files that make no reference to drive C. As resources, use the current AUTOEXEC.BAT and CONFIG.SYS files on the hard drive and the documentation to the CD-ROM drive.

Sound When Starting Windows 9x

1. Load the Windows Sound Recorder: click **Start**, **Programs**, **Accessories**, **Multimedia/Entertainment**, **Sound Recorder**.

2. Connect a microphone to the MIC jack on the sound card at the back of the computer.

3. Press the **Record** button and record a greeting message such as "Welcome to my computer." Keep the greeting short, as the file can get quite large.

4. Click **File**, **Save as**, and then save the file as "Greeting" in the directory of \Windows\Start Menu\Programs\Startup.

5. Reboot the computer, and your greeting should automatically play.

Comparing Sound Quality

1. Load the Windows Sound Recorder: click **Start**, **Programs**, **Accessories**, **Multimedia**/**Entertainment**, **Sound Recorder**.

2. Insert a music CD in the CD-ROM drive.

3. Press record in the sound recorder window and record a 15-second sound clip.

4. Click **File**, **Save As** and save it as "SoundEx."

5. Open Windows Explorer, find "Sound Ex," and note its file extension and also its file size.

6. From the Sound Recorder window, click on **Edit**, **Audio Properties**, and **Performance**. Change the **Sample Rate Conversion Quality** and save the file with a different name. Compare both the sound quality and file sizes of the two saved files.

Windows 9x Sound Properties

Using a PC with a sound card and speakers, create your own customized Windows 9x sound scheme using at least six events and four different sounds. Save the sound scheme file to a floppy disk. Take the file to another PC and install the sound scheme there.

Using MMX Technology

Research the market and list five software packages that claim to use MMX technology. *Hint*: See the Intel Web site for a list of software that uses MMX. The Web site is *www.intel.com*.

Troubleshooting Skills

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1. A friend calls to say that he has just purchased a new sound card and speakers to install in his PC and wants some help from you over the phone. The PC already has a CD-ROM drive installed. Your friend has already installed the sound card in an expansion slot and connected the audio wire to the sound card and the CD-ROM drive. List the steps you would guide him through to complete the installation.

2. Suppose, in the previous situation, the audio wire connection does not fit the connection on the CD-ROM drive. You think that if the problem is that the audio wire will not work because of a wrong fit, perhaps you can improvise to connect audio from the CD-ROM drive directly to the sound card. You notice that the CD-ROM drive has a port for a headphones connection, and the sound card has a port for audio in. How might you improvise to provide this direct connection? Check your theory using the appropriate audio wire.

3. Work with a partner. Each of you set up a problem with a PC and have the other troubleshoot the problem. Some suggestions as to what problem to set up are:

   ❑ Speaker cables disconnected

   ❑ Speaker turned off

   ❑ Speaker cable plugged into the wrong jack

   ❑ Volume turned all the way down

   ❑ MSCDEX.EXE not called in the AUTOEXEC.BAT file for DOS

   ❑ MSCDEX.EXE file missing

   As you troubleshoot the problem, write down the initial symptoms of the problem and the steps you take towards the solution.

Using the Internet for Research

Make a presentation or write a paper about digital cameras: what features to look for when buying one, and how to compare quality from one camera to another. Use these web sites and also include in the results of your research three more web sites that were useful.

www.imaging-resource.com

www.pcphotoreview.com

www.steves-digicams.com

Entertainment from the Internet

Use the *www.on2.com* web site by on2.com, Inc. to view a video clip from the web site. This web site uses Shockwave, a software product of Macromedia, Inc. (*www.shockwave.com)*. Shockwave downloads a web browser plug-in (software that a browser can use to display data from a web site) to your PC and uses the Shockwave software on the PC and on the web site to attain streaming video.

Additional Activities

1. On your home or lab computer, find out what IRQ is used for the CD-ROM.

2. Play a music CD with the Windows CD Player.

3. Change Windows sounds through the Control Panel Sounds icon.

4. Record a voice message using the Sound Recorder.

5. Set up one of the following troubleshooting practice problems and have a fellow student discover the problem and the solution.

   a. Speaker cables disconnected

   b. Speaker turned off

   c. Speaker cable plugged into the wrong jack

   d. Volume turned all the way down

   e. MSCDEX.EXE not called in AUTOEXEC.BAT file

   f. MSCDEX.EXE not on drive

6. Use the Hardware Wizard to remove the CD-ROM drivers, and then reinstall the CDROM.